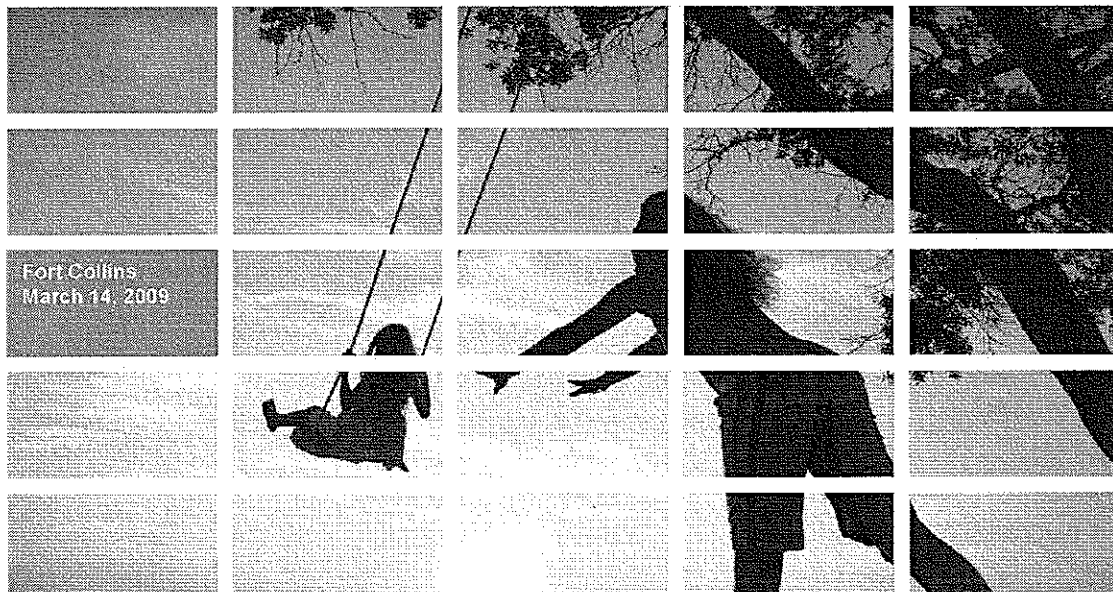




CdCl₂ Rinse and Reclaim Roadmap



Overview: Problem Statement and Opportunity

Problem Statement

The current method of rinsing the panels post-chamber involves the use of resin filters to purify the rinse water for reuse by the rinse tool. The aggregate cost for these filters, their change-in and change-out, and their disposal (as hazardous waste) is approximately \$5.70/module, not including lost opportunity cost of CdCl₂ material thrown away.

Opportunities

- Reduce filter use (quantity)
- Reduce filter cost (filter design)
- Reduce disposal costs (filters, concentrate)
- Reclaim CdCl₂ chemical for reuse (concentrate, purify, dry), reduces environmental impact.

Current state

1 resin filter costs \$60 which cleans 14 panels or \$4.28 per panel
Hazardous waste haul off costs = \$1.40 per panel
 $\$5.68 \text{ per panel} \times 2880 \text{ panels per day} \times 365 \text{ days} = \$5.9\text{M Disposal Cost}$

30 grams per panel x 2 panels per minute = 60 grams per minute
60 grams per minute x 60 minutes = 3600 grams x 24 hours
86,400 grams per day available for recovery = 864 kilos

$864 \text{ Kg} \times \$100/\text{kg} \times 365 = \$3.1\text{M Material Cost}$

Total cost of CdCl_2 = \$9M per year per cell

Roadmap Moving Forward

Phase-1: Redesign filtration system – Dual Selective Resins

- Reduce filter cost (scale up filter size)
- Reduce filter disposal cost (new filter design reclassifies waste stream)

Phase-2: Implement Reverse Osmosis plus Evaporation system

- Concentrates CdCl₂ waste stream into slurry
- Slurry can be disposed of or stored for future reclaim (preferred)
- Water distillate stream requires very small ion filter for reuse

Phase-3: Add Recrystallizer to enable CdCl₂ Reclaim

- Requires Qualification within the Semi Tool
- Requires significant EPA approvals regarding storage of Phase-2 CdCl₂ slurry, see following slide for excerpts from the regulation

Note: Phases-2 and -3 are not independent, just a matter of timing (ie, we would not choose to do only Phase-2). Phase-1 is independent of Phases-2, -3.

Title 40 : Protection of Environment

We believe Abound is exempt from the 90 day hazardous waste rule under the following provision:

A person who generates a solid waste, as defined in 40 CFR 261.2, must determine if that waste is a hazardous waste using the following method:

(a) He should first determine if the waste is excluded from regulation under 40 CFR 261.4.

40 CFR § 261.4(a-b)

§ 261.4 Exclusions

(a) Materials which are not solid wastes. The following materials are not solid wastes for the purpose of this part:

(8) Secondary materials that are reclaimed and returned to the original process or processes in which they were generated where they are reused in the production process.

Commentary: If we store CdCl₂ slurry in barrels, we can only store a 90-day amount of waste stream (even if we intend to remove it from the barrel for future reclaim). If we store CdCl₂ slurry in tanks for future reclaim, we can only store 1-years amount of waste and then we must reclaim at least 75% of that waste the following year. This scenario requires advance EPA approval. Slurry stored in tanks could be later transferred to barrels for disposal if we so chose to.

Phase-1: CdCl₂ Regeneration with Cation/Anion Division and Selective Resin Technology

By processing the CdCl₂ rinse tool water through a cation bed first then anion we have effectively separated the hazardous Cadmium from the non hazardous Chloride.

The hazardous Cadmium is then bonded the with cation resin resulting in a non hazardous resin/Cadmium material much like our glass after sublimation it still contains Cadmium but will pass TCLP.

Toxicity Characteristic Leaching Procedure is EPA testing which characterizes the waste as hazardous or non hazardous for the purpose of disposal

The Chloride is processed through the anion as non hazardous brine and the pure DI water is returned to the Bilco rinse tool

Phase-1: Regeneration with 30 Cubic foot tanks with Selective Resin Filters

\$ 130 per cubic foot includes full service

Pickup, replace, and monitor by Culligan

30 cu ft regen will process 10K modules @ \$3900,
reduces change-out frequency

Total cost is \$0.39/module

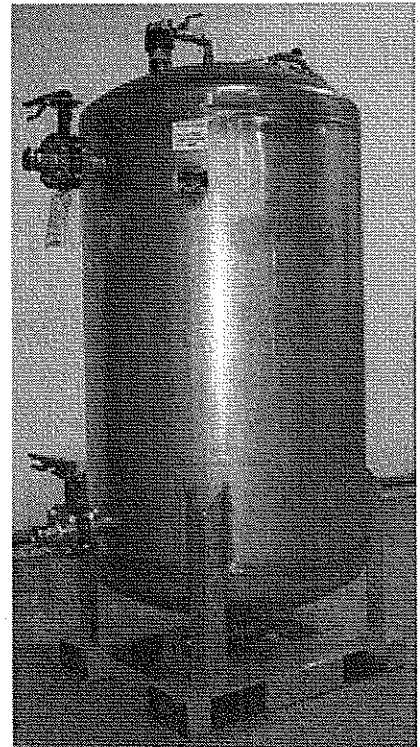
Capex needed is \$35K

100% ROI equals <1- 30 cu ft tank or 7000 modules

3 week lead time

100 Sq ft footprint

Buys us time to properly implement Phases-2+3



Phase-2/3 Overview: 2-stage Reverse Osmosis followed by Evaporation, then Recrystallization

Phase-2

- Reverse Osmosis plus Evaporation- concentrates the CdCl₂ into a slurry for either disposal or storage, can use waste process heat if so designed.
- Capex \$75k
- 3 week lead time
- $\$3141/2880 \text{ modules} = \$1.10/\text{module}$ if we disposed of Slurry in barrels, \$0.03/module if we stored the Slurry in tanks (but there is a 1 year storage limit before we must begin reclamation so this does not scale)
- Preferred would be to store the Slurry in tanks for Phase-3 reclaim

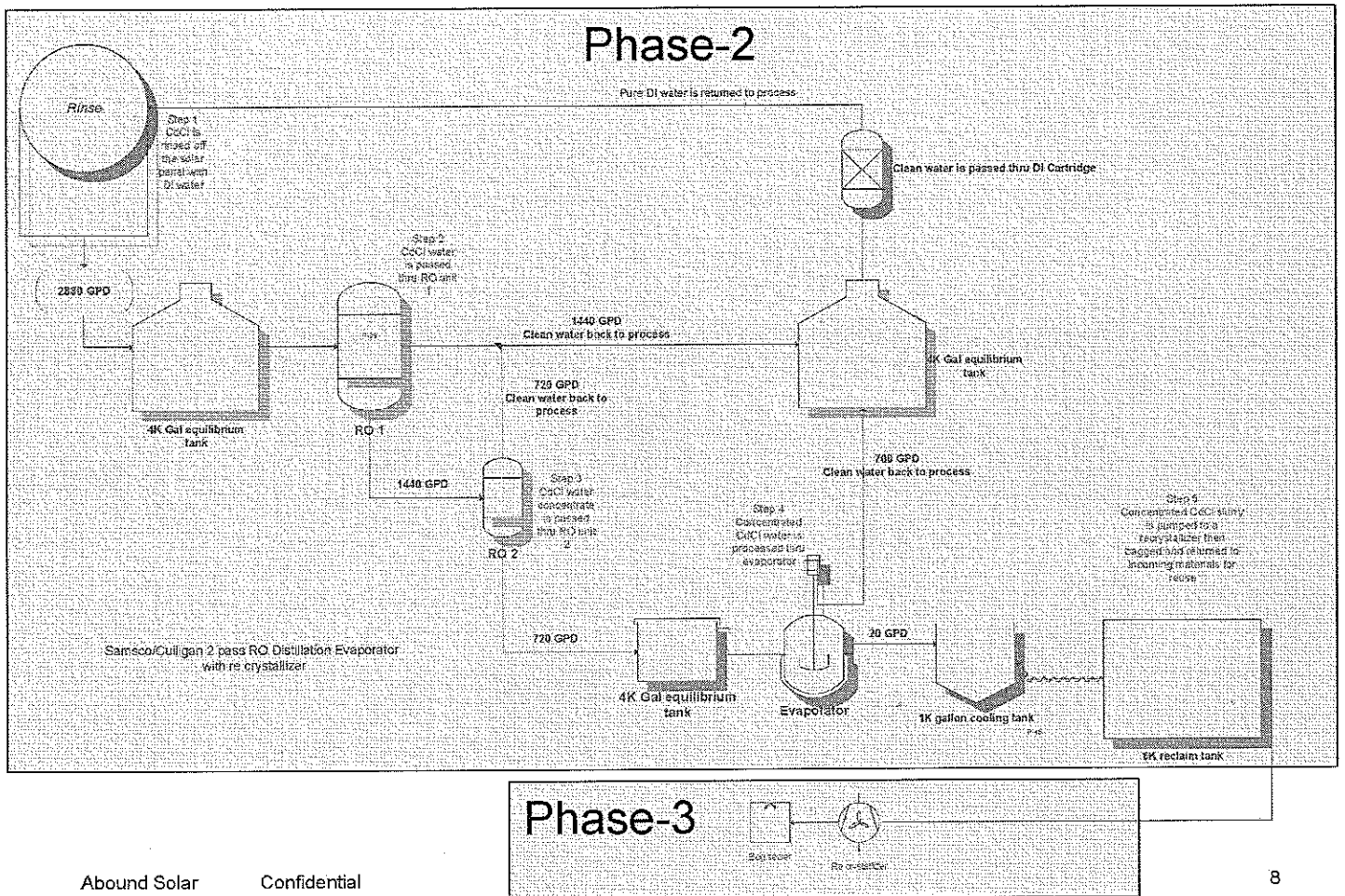
Phase-3

- Adds a recrystallizer to produce dried CdCl₂ for use in the semi tool. Can also use waste process heat if so designed.
- Capex \$350k
- 12 week lead time
- $\$240/2880 \text{ modules} = \$0.10/\text{module}$

Notes:

- \$15k/year Operating and Maintenance costs included in the \$/module
- Capex figures do not include facility readiness or installation, therefore the Capex budget request for this project was \$550k

Phase-2/3 Design: 2-stage Reverse Osmosis followed by Evaporation, then Recrystallization (sizes not to scale)



Next Steps

or settlement shall be binding upon the Borrower for purposes of this Section 11.17

(i) Upon payment of any Claim by the Borrower or the Sponsor pursuant to this readings, Implement Phase-1 ASAP PR PACKAGE PREPARED AND READY FOR SUBMITTAL

Submit a letter outlining the proposed process for review and approval by regional EPA for Phases 2 and 3 - DONE, MEETING REQUEST ALSO SUBMITTED (J. SHOBAR)

Define footprint, factory location and fit up costs for Phases 2 and 3 - OPEN

Engage consultants (likely Stewart Environmental) for assistance in ensuring compliance with EPA requirements - BEGUN

Finalize design, plan, timeline, and PO for approval - OPEN